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Distribution and floral hosts of *Anthophorula micheneri* (Timberlake, 1947) and *Hylaeus sparsus* (Cresson, 1869), (Insecta: Hymenoptera: Apoidea: Anthophila), with new state records in Giles and Loudoun counties, Virginia, eastern USA

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Abstract: New collection records for *Anthophorula micheneri* (Timberlake, 1947) from Loudoun County and other locations in Virginia, USA document an approximately 1,350 km extension of its previously recorded geographic range. New state records for the rarely seen *Hylaeus sparsus* (Cresson, 1869) collected in Giles County and from a blue vane trap in Loudoun County, Virginia add to our knowledge of this species' range and phenology in the USA. Floral records for both species are documented with a discussion of possible host preferences.

Key words: blue vane trap, plant associations, Apiaceae, *Agalinis*, range extension, Apidae, Colletidae

An inventory of bee species (Hymenoptera: Apoidea) was conducted from March to October 2010 and from February to October 2011 at Banshee Reeks Nature Preserve (BRNP), Loudoun County, Virginia, USA. The inventory resulted in a new distribution record for *Anthophorula micheneri* (Timberlake, 1947) indicating either a possible range extension or more likely a confirmation of a previously broader range than is currently known; and a new distribution record for the uncommonly collected *Hylaeus sparsus* (Cresson, 1869). Both *A. micheneri* and *H. sparsus* are represented in United States and Canadian collections by a limited number of specimens, consequently little information is available regarding their geographic distribution, ecological behavior, preferred habitats, and potential plant associations in North America.

The Banshee Reeks Nature Preserve is a 293 ha preserve located in the northern piedmont region or foothills of the Blue Ridge Mountains in Loudoun County, Virginia, USA (39.029586°, −77.598799°, 80–105 m elevation). The Preserve includes old agricultural fields and wetland habitats colonized by native and introduced herbs and shrubs; a rare mountain/piedmont basic seepage swamp community; and mixed hardwood forests of oak (*Quercus* spp.), walnut (*Juglans* spp.), and hickory (*Carya* spp.) and is bordered in the south and southwest by Goose Creek. In 2010, six sites were selected at BRNP to sample bee species occurring in a variety of habitats including upland forest (site 1), open grassland (site 2), savannah (site 3), pond edge/pine forest (site 4), successional field (site 5), and mountain piedmont basic seepage swamp (site 6). Site 5, from which the *A. micheneri* specimen was collected, was located west of the intersection of the Western Watercress and Greenway trails at the BRNP (39.0256°, −77.5898°, 87.8 m elevation). Dominant flowering plants at site 5 included multiflora rose (*Rosa multiflora* Thunb.) and autumn olive (*Elaeagnus umbellata* Thunb.) (Figure 1).

Sampling materials and methods used to conduct this inventory are detailed in Droege (2012). While examination of the efficacy of different sampling methods was not a specific goal for this study, a combination of 96 ml or 3.25 U.S. fluid oz plastic Solo® cup pan traps (plain white, and painted fluorescent yellow, and fluorescent blue) placed on the ground or elevated with wire stakes (where thick vegetation prevented ground placement); 2 L plastic blue vane traps (blue vanes, white bottle) suspended in tree canopies, and hand netting methods were used in order to collect as great a variety of species as possible. Different colored pan traps were used because they have been shown to attract different bee species. In one example from a prairie restoration study, blue colored pan and vane traps in particular, have been shown to attract a greater number of individuals and

Figure 1. Pan trap filled with a solution of water and blue Dawn® dish-washing liquid in an elevated wire pan trap holder at Site 5 (Successional Field; from which the *Anthophorula micheneri* specimen was collected), Banshee Reeks Nature Preserve, Loudoun County, Virginia, USA (39.0256S, -77.5898W, 87.8m elev.). Multiflora rose (*Rosa multiflora*) is flowering in the background. Credit: Elizabeth Sellers, 20 May 2011.

variety of species than yellow colored traps (Geroff et al. 2014). The pan traps were filled to ¾ of their volume (a depth of approximately 3 cm) with a solution of water and blue Dawn® dishwashing liquid and placed on the ground or in elevated wire trap holders (Figure 1). The vane traps were filled to 2.5 cm depth with a solution of red dyed propylene glycol and blue Dawn® dishwashing liquid. Propylene glycol was used in the vane traps, which would be operated for longer periods (up to two weeks at a time), because of its slower evaporation rate and preservative properties. Pan trap sampling began when daytime high temperatures were above 18°C (65°F). Every two weeks, 30 alternating color pan traps were placed 5 m apart along a 150 m linear transect or circular array (Site 5 only) at each site before 9 am Eastern Time (ET) and removed after 5 pm ET. Pan traps were placed at site 5 at 7:40 am ET and retrieved at 6:15 pm ET on 6 September 2010 by David McCarthy.

Blue vane traps were added to the sampling methodology in 2011 to more effectively sample bee species that may forage in the canopy of flowering trees, especially early in spring (Ulyshen et al. 2010). Trees selected for blue vane trap sampling were separate from and did not fall within pan-trapping sites 1–6. They were selected opportunistically from a variety of locations across the Preserve based on their accessibility (e.g., height, approachability on foot); their position in relation to other flowering trees of the same species (e.g., center of a monospecific stand); and their flowering status (e.g., buds forming or about to open). Blue vane traps were hung from branches of selected trees using green wire hooks prior to buds opening or as early as possible in the flowering period and samples were collected from them every two weeks until the trees stopped flowering. Care was taken to position the vane traps among or as close to canopy flowers and if possible, on the east side of trees to reduce wind exposure. On 23 April 2011, a blue vane trap was hung in a flowering pawpaw tree (*Asimina triloba* (L.) Dunal) in a stand of 3–4 individuals of the same species, located at the southern end of the Cathedral trail on the banks of Goose Creek, BRNP, Loudoun County, VA, USA (39.0216°, −77.5981°, 82 m elevation) (Figure 2). Specimens were collected from the vane trap on 20 April 2011 (when the propylene glycol and Dawn® solution was also refreshed), and again on May 6.

Weather conditions and flowering plants were observed and recorded during sampling. Daytime high temperatures recorded by the nearby (5 km away) Leesburg Executive Airport weather station (KJYO) were referenced for this study site.

Specimens collected at BRNP were prepared, pinned, labeled, identified and deposited in the Smithsonian National Museum of Natural History's National Collection (NMNH), Washington, District of Columbia, USA. The specimen labels included a unique data matrix symbol generated using Discover Life's Web Labeling System (http://www.discoverlife.org/label/). Electronic data associated with each BRNP specimen are accessible from the United States Geological Survey (USGS) Patuxent Wildlife Research Center (PWRC) Native Bee Inventory and Monitoring Lab (BIML) database that is hosted online by Discover Life (http://www.discoverlife.org), a project administered by the 501-C3 non-profit Polistes Foundation; and also available for download from the USGS Biodiversity Information Serving Our Nation (BISON) mapping application (http://bison.usgs.ornl.gov/). The USGS will also soon make these

Figure 2. Blue vane trap (from which the *Hylaeus sparsus* specimen was collected) hanging in a flowering pawpaw tree (*Asimina triloba* (L.) Dunal). Credit: Elizabeth Sellers.

and other records in the USGS PWRC BIML database available through the Global Biodiversity Information Facility (GBIF) (http://www.gbif.org). All scientific names used in this article were validated against the Integrated Taxonomic Information System (ITIS) (http://www.itis.gov) and the Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila) (Ascher and Pickering 2014; ITIS 2014). Additional collection and distribution records for both bee species and the plant species off which they were collected (where available) were solicited and obtained directly from published literature and museum, university, and researchers' private collections (Tables 1 and 2). The taxonomic literature describing *A. micheneri* and *H. sparsus* was also examined to inform search and detection of historical collection records (Cresson 1869; Robertson 1898, 1929; Lovell, 1901; Metz 1911; Timberlake 1947, 1980; Michener and Moure 1957; Krombein 1958; Hurd 1979; Mitchell 1951, 1960, 1962; Snelling 1968, 1970; Silveira 1995; Michener 1942, 2007; Edens-meier et al. 2011; Moure et al. 2012; Poole and Gentili 2014).

Taxonomic determinations for the *A. micheneri* and *H. sparsus* specimens collected at BRNP were completed by S. Droege (USGS, Patuxent Wildlife Research Center, Native Bee Inventory and Monitoring Laboratory, Beltsville, MD, USA). The male *A. micheneri* specimen was identified using the Discover Life *Anthophorula* Guide (http://www.discoverlife.org/mp/20q?guide=Anthophorula) and the keys in Mitchell (1962) and associated species accounts. It was also compared with specimens at the NMNH of both *A. micheneri* and *A. asteris* (Mitchell, 1962) and was distinguished from the latter by the extensive dark or black areas around the basal and lateral areas of the clypeus with the central and apical regions yellow.

The male *H. sparsus* specimen was identified using the Discover Life *Hylaeus* Male Guide (http://www.discoverlife.org/mp/20q?guide=Hylaeus_male) and the keys in Mitchell (1960). It is distinguished in particular by the pointed shape of the front coxae.

A male specimen of *A. micheneri* was among the 58 specimens collected by David McCarthy from pan traps at site 5 on 6 September 2010. Carolina horsenettle (*Solanum carolinense* L.) was the only plant recorded in flower at site 5 on this date. The weather recorded that day included a clear sky with a temperature of 18°C (65°F) at 7:40 am ET when the pan traps were placed, and a maximum of 29°C (85°F) for the day. A male specimen of *H. sparsus* was collected in a sample of five specimens removed from the pawpaw tree blue vane trap by Elizabeth Sellers at 10:30 am ET on 6 May 2011. No other plants were observed in flower within sight of the pawpaw tree at the time of sampling on 6 May 2011.

Anthophorula micheneri (Timberlake) (Apidae: Apinae: Exomalopsini)

Subsequent to the collection of *Anthophorula*

Table 1. *Anthophorula micheneri* (Timberlake, 1947) occurrences in the United States (AMNH – American Museum of Natural History*, New York, NY, USA; CTMI – Central Texas Melittological Institute; KNHM / UKBI – Kansas Natural History Museum / University of Kansas Biodiversity Institute, Snow Entomological Museum; NMNH – Smithsonian National Museum of Natural History, Washington, D.C., USA; USDA-ARS – United States Agriculture Research Service Bee Biology and Systematics Laboratory (BBSL), Logan, UT, USA; USGS PWRC – United States Geological Survey, Patuxent Wildlife Research Center, Native Bee Inventory and Monitoring Lab, Beltsville, MD, USA). *Specimen records in the AMNH Division of Invertebrate Zoology database AMNH (Schuh et al. 2010) were captured using Arthropod Easy Capture (2013) software.

Virginia
USA: Virginia: Westmoreland Co., George Washington Birthplace National Memorial, Virginia Beach, 5 Sept. 2013, col. R. Morawe, det. S. Droege, 20 Dec 2013 (1 ♂ USGS PWRC, USGS_DRO365321)
USA: Virginia: Loudoun Co., BRNP, Site 5, 6 Sept 2010, col. D. McCarthy, det. S. Droege, 22 Dec. 2010 (1 ♂ USGS PWRC, USGS_DRO182907)
USA: Virginia: Prince William, Stafford, Fauqier Co., Quantico Marine Base; off *Agalinis setacea* (J. F. Gmel) Raf. (as *Gerardia setacea*), 10 Oct 1983, det. S. Droege (Orig. det. Eickwort as *Exomalopsis micheneri*) (2 ♀ NMNH)
Mississippi
USA: Mississippi: Lamar/Forrest Co., Camp Shelby, near Hattiesburg; off *Agalinis purpurea* (L.) Pennell (as *Gerardia purpurea*), 3 Oct 1944, col. C. D. Michener, det. Timberlake as *Exomalopsis micheneri* (2 ♀ AMNH-not databased; KNHM KSEM417628?) (Timberlake 1947)
USA: Mississippi: Lamar/Forrest Co., Hattiesburg; off *Agalinis purpurea* (L.) Pennell (as *Gerardia purpurea*), 10 & 24 Oct 1943; 8 & 14 Oct 1944, col. C. D. Michener, det. Timberlake as *Exomalopsis micheneri* (15 ♀, 2 ♂ AMNH (8 paratypes, 1 ♀ - not databased); USDA-ARS BBSL508870; NMNH) (Timberlake 1947)
USA: Mississippi: Lamar Co., Hattiesburg; off *Agalinis purpurea* (L.) Pennell (as *Gerardia purpurea*), 10 Oct 1943, col. C. D. Michener, det. Timberlake as *Exomalopsis micheneri* (1 ♀ holotype AMNH-not databased, 1 ♂/♀ KNHM KSEM417670?) (Timberlake 1947)
Texas
USA: Texas: Travis Co., Brackenridge Field Lab (BFL), Austin; off *Agalinis strictifolia*, 26 Sept 2010, col. J. L. Neff, det. J. L. Neff (3 ♂ CTMI 34591; 34592; 34593 and 3 ♀ CTMI 34588; 34589; 34596)
USA: Texas: Travis Co., Brackenridge Field Lab (BFL), Austin; off *Agalinis strictifolia*, 2 Oct 1994, col. J. L. Neff, det. J. L. Neff (1 ♀ CTMI 07177)
USA: Texas: Travis Co., Brackenridge Field Lab (BFL), Austin; off *Agalinis strictifolia*, 9 Sept 1994, col. J. L. Neff, det. J. L. Neff (2 ♀ CTMI 07158; 07159)
USA: Texas: Fayette Co., Flatonia; off *Agalinis purpurea* (L.) Pennell (as *Gerardia purpurea*), 12 Sept 1970, col. Baker, Kamm, Michener, det. Timberlake (98 ♂/♀ KNHM KSEM417684; KSEM417735; KSEM417631; KSEM417633;
KSEM417718; KSEM417667 and USDA-ARS BBSL508868 ♂; BBSL508869 ♀)
USA: Texas: Brooks Co., Falfurrias, 1907, col. A. C. Morgan, det. S. Droege (1 ♀ NMNH *may be misidentified/mislabeled)

Table 2. *Hylaeus sparsus* (Cresson, 1869) occurrences in the United States and Canada (AMNH – American Museum of Natural History*, New York, NY, USA; CAES – Connecticut Agricultural Experiment Station; CTMI – Central Texas Melittological Institute; DEBU – University of Guelph Insect Collection, Guelph, Ontario, Canada; GU – Georgetown University, Washington, D.C., USA; INHS – Illinois Natural History Survey (2014) Insect Collection, Champaign, IL, USA; ISU/SMWC – Indiana State University, Saint Mary of the Woods College, R. P. Jean Collection, IN, USA; MSUC/ARC – Michigan State University Collections, Albert J. Cook Arthropod Research Collection, East Lansing, MI, USA; NCSU – North Carolina State University Insect Museum, Raleigh, NC, USA; NMNH – Smithsonian National Museum of Natural History, Washington, D.C., USA; PCYU – Packer Collection, York University, Toronto, Canada; UCMS – University of Connecticut Insect Collection; RSKM – Royal Saskatchewan Museum, Regina, Saskatchewan, Canada; USGS PWRC – United States Geological Survey, Patuxent Wildlife Research Center, Native Bee Inventory and Monitoring Lab, Beltsville, MD, USA). *Specimen records in the AMNH Division of Invertebrate Zoology database AMNH (Schuh et al. 2010) were captured using Arthropod Easy Capture (2013) software.

Eastern Canada
Canada: New Brunswick
Canada: New Brunswick: Fredericton, Jul 1967, col. N. L. H. Krauss (1 ♀ NMNH)
Central Canada
Canada: Ontario
Canada: Ontario, Algonquin Provincial Park, 28 Jun - 11 Jul 2011, col. E. Nardone (1 ♀ PCYU UGEN0004119) (Nardone 2013)
Canada: Ontario, Algonquin Provincial Park; off *Cornus canadensis*, 15 Jun 2011, col. E. Nardone (1 ♀ PCYU UGEN0004164) (Nardone 2013)
Canada: Ontario, Algonquin Provincial Park, 30 Jun 2010, col., E. Nardone (1 ♀ PCYU UGEN0004069) (Nardone 2013)
Canada: Ontario, St. Catherines, 6 May 2009, col. T. M. Onuferko, det. T. M. Onuferko (1 ♀ T. M. Onuferko Private Collection) (Onuferko 2013)
Canada: Ontario, Kent Co., Rondeau Provincial Park, South Point Trail, near east parking lot, 3 – 16 Jul 2003, col. S. Marshall et al. [sic] (2 ♂/♀ DEBU-Rondeau Survey debu01135122; debu0113527) (Marshall 2009; Canadensys.net 2014)
Canada: Ontario: Essex Co., Pelee Island, Stone Road Alvar, [Federation of Ontario Naturalists] (FON) Res. (Lake Erie Islands), 9 Jun 2002, col. M. Buck (1 ♂/♀ DEBU – Point Pelee and Erie Islands debu00181892) (Canadensys.net 2014; University of Guelph 2014)
Canada: Ontario: Middlesex Co., London, 25 Jun 1981, col. D. G. Krementz (1 ♀ USDA-ARS BBSL)
Canada: Québec
Canada: Québec: Montréal, 10 Jun 1906, col. unknown, det. as *Prosopis potens* Metz 1911 (1 ♀ C. F. Baker Collection, Pomona College, Claremont, CA, USA)
Canada: Saskatchewan
Canada: Saskatchewan, Wood Mountain Regional Park, 1 Aug 2013, col. C. S. Sheffield, K. Sheffield, det. C. Sheffield (2 ♀ RSKM) (Sheffield et al. 2014)
Eastern United States
USA: Maine
USA: Maine, date unknown, col. unknown (AMNH_BEES1582 *unconfirmed)
USA: New Hampshire
USA: New Hampshire: Grafton Co., Easton, along a fire road; off *Lupinus* sp., 29 May 2010, col., M. Veit, det. M. Veit (1 ♂ M. Veit Private Collection)
USA: Vermont
USA: Vermont: Addison Co., 18 Jul 1960, col. R. A. Morse, det. R. Snelling (1 ♂/♀ MSUC/ARC)
USA: New York
USA: New York: Kings Co., Prospect Park, Wellhouse, between Prospect Lake and Lookout Hill, 3 Jun 2012, col. J. S. Ascher, det. J. S. Ascher (1 ♀ AMNH_BEE00220206)
USA: New York: Bronx Co., Mosholu, 2 Jun 1918, col. unknown, det. J. S. Ascher, 2012 (1 ♀ AMNH_BEE00163602)
USA: New York: Clinton/Essex Co., Keeseville, 2 Jun 1918, col. A. K. Fisher (1 ♂ NMNH)
USA: Connecticut
USA: Connecticut: New London Co., Montville Powerline ROW, Site 2, 12 May 2012, col. B. Gagliardi, N. Schoppmann, det. J. S. Ascher, 2012 (1 ♂ UCMS_ENT00050748)
USA: Connecticut: New London Co., Montville, utility pole 348, woodland, 31 May 2012, col. M. Gould, N. Schoppmann, V. Bruzzese, det. J. S. Ascher, 2012 (1 ♀ UCMS_ENT00050749)
USA: Connecticut: New Haven Co., Beacon Falls, 14 May 1934, col. G. H. Plumb, det. J. S. Ascher, 2008 (1 ♂ CAES UCMS_ENT00030533)
USA: Connecticut: Fairfield Co., Newtown, 1 Jun 1933, col. T. Turner, det. J. S. Ascher, 2008 (1 ♂/♀ CAES UCMS_ENT00030534)
USA: Pennsylvania
USA: Pennsylvania, 1867, col. E. T. Cresson, det. as *Prosopis sparsa* Cresson 1869 (1 ♀ lectotype)
USA: Pennsylvania: Bucks Co., Site:Bowmans; ♂ off *Zizia aurea*; ♀ off *Erigeron philadelphicus*, 24 May 2007, col. J. Stager, det. J. S. Ascher (1 ♂ 1 ♀ Winfree Laboratory Collection, Rutgers University-New Brunswick nsf200707188; nsf200707171)
USA: Pennsylvania: Bucks Co., Site:Bowmans; off *Zizia aurea*, 23 May 2007, col. J. Stager, det. J. S. Ascher (1 ♀ Winfree Laboratory Collection, Rutgers University-New Brunswick nsf200707118)
USA: Pennsylvania: Bucks Co., Site:Bowmans; off *Zizia aurea*, 15 May 2007, col. J. Stager, det. J. S. Ascher (1 ♀ Winfree Laboratory Collection, Rutgers University-New Brunswick nsf200706676)
USA: Pennsylvania: Bucks Co., Site:Bowmans; off *Zizia aurea*, 9 May 2007, col. J. Stager, det. J. S. Ascher (1 ♂ Winfree Laboratory Collection, Rutgers University-New Brunswick nsf200706765)
USA: Pennsylvania: Bucks Co., Site:Bowmans: off *Osmoriza longistylis*, 10 May 2006, col. S. Droege, det. J. S. Ascher (1 ♂/♀ Winfree Laboratory Collection, Rutgers University-New Brunswick nsf200600619)
USA: New Jersey
USA: New Jersey: Burlington Co., Site:Strafford Ct. [Medford]; off *Euonymus alatus*, 20 May 2003, col. B. Ahlstrom, det. J. Gibbs (1 ♂ Winfree Laboratory Collection, Rutgers University-New Brunswick pine2003 – pine_1325.1) (Winfree et al. 2007)
USA: Maryland
USA: Maryland: Wicomico/Worcester Co., 12 May 2009, col. J. Frye, det. R. P. Jean (1 ♀ State of Maryland DROEGE-695)
USA: Maryland: Montgomery Co., 4 miles SW of Ashton, 8 Jun 2002, col. G. F. Hevel, det. G. F. Hevel (1 ♂/♀ G. F. Hevel Private Collection)
USA: Maryland: Montgomery Co., 4 miles SW of Ashton, 16 May 2001, col. G. F. Hevel, det. G. F. Hevel (1 ♂/♀ G. F. Hevel Private Collection)

Continued

Table 2. *Continued.*

USA: Maryland: Allegany Co., Green Ridge State Forest, 1991 – 1993, col. E. Barrows (1 ♂/♀ GU Droege-1059)
USA: Maryland: Montgomery Co., Plummers Island, 10 May 1985, col. R. McGinley, det. S. Droege (1 ♀ NMNH Droege-554)
USA: Virginia
USA: Virginia: Loudoun Co., Banshee Reeks Nature Preserve (BRNP), Pawpaw, Cathedral trail, 30 Apr – 6 May 2011, col. E. Sellers, det. S. Droege Jul 26 2011 (1 ♂ USGS PWRC USGS_DRO213808)
USA: Virginia: Giles Co., Cascade Falls [Little Stoney Creek], 22 May 1997, col. N. Luth (1 ♀ DEBU)
USA: North Carolina
USA: North Carolina: Swain Co., Great Smoky Mountain National Park, Big Cove Road, Site #1, 28 Apr – 4 May 2000, col., Col. B. M. Weigmann, B. K. and Cassell (1 ♂/♀ NCSU10325)
USA: North Carolina: Buncombe Co., Mt. Pisgah, 23 Jun 1934, col. T. B. Mitchell (2 ♀ NCSU10322) (Romankova 2007)
USA: North Carolina: Wake Co., Raleigh, 2 Jul 1931, col. C. S. Brimley (1 ♂/♀ NCSU10324)
USA: South Carolina
USA: South Carolina: Anderson Co., Pendleton, Tanglewood Spring, 6 May 1987, col. J. Morse (1 ♂ PCYU UGEN0005143)
USA: Georgia
USA: Georgia: Clarke Co., 2011, col. J. Hudson, det. J. L. Hanula (2 ♂/♀ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Hudson 2013; Ascher 2014)
USA: Georgia: Putnam Co., 2008, col. J. L. Hanula, S. Horn, det. J. L. Hanula (3 ♂ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Ascher 2014)
USA: Georgia: Greene Co., 2007, col. J. L. Hanula, S. Horn, det. J. L. Hanula (6 ♂ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Ascher 2014)
USA: Georgia: Oglethorpe Co., 2007, col. J. L. Hanula, S. Horn, det. J. L. Hanula (8 ♂ 1 ♀ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Ascher 2014)
USA: Georgia: Clarke Co., 2007, col. J. L. Hanula, S. Horn, det. J. L. Hanula (5 ♂ 1 ♀ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Ascher 2014)
USA: Georgia: Clarke Co., 2006, col. J. L. Hanula, S. Horn, det. J. L. Hanula (2 ♂ J.L. Hanula, S. Horn Collection) (Hanula and Horn 2011; Ascher 2014)
USA: Georgia: Oglethorpe Co., Scull Shoals Experimental Forest, Oconee National Forest, 5 Apr – 28 Jun; 12 Jul – 4 Oct 2005, col. M. D. Ulyshen, V. Soon, J. L. Hanula, det. J. L. Hanula (2 ♂/♀) (Ulyshen et al. 2010)
Central United States
USA: North Dakota
USA: North Dakota: Fargo; off *Zizia aurea*, 20 Jun 1914, col., O. A. Stevens, det. J. S. Ascher; Orig. det. Stevens as *Prosopis ziziae* Rob. (1 ♀ AMNH_IZC170456; AMNH_BEES1595)
USA: Michigan
USA: Michigan: Midland Co., 17 Jun 1945, col. R. R. Dreisbach (1 ♀ MSUC/ARC)
USA: Michigan, 26 Jun 1888, col. unknown (2 ♂/♀ MSUC/ARC)
USA: Indiana
USA: Indiana: Newton Co., Region 1nw, Conrad_Savanna, TNC (Lake township); off *Zizia aurea*, 4 Jun 2003, col. R. P. Jean, det. R. P. Jean (2 ♀ ISU/SWMC ISU-TH7459; ISU-TH7465)
USA: Indiana: Starke Co., Region 1nw, Ober_Savanna, TNC, Washington; off *Zizia aurea*, 30 May 2002, col. R. P. Jean, det. R. P. Jean (1 ♂ ISU/SMWC ISU-TH4528)
USA: Indiana: Parke Co., Region 4cw, Coxville_2miN, Florida; off *Phacelia purshii* and *Rubus allegheniensis*, 15 May 2002, col. R. P. Jean, det. R. P. Jean (5 ♂ ISU/SMWC ISU-TH4318; ISU-TH4319; ISU-TH4324; ISU-TH4326; ISU-TH4336)
USA: Indiana: Harrison Co., Region 8sc, 6 May 1965, col. R. T. Everly, det. R. P. Jean (1 ♂ SMWC)
USA: Illinois
USA: Illinois: Macoupin Co., Carlinville, 20 May 1972, col. J. C. Marlin, det. W. E. LaBerge (2 ♂/♀ INHS IC-368877; IC-368878)
USA: Illinois: Macoupin Co., Carlinville, 13 Jun 1904, col. C. A. Robertson, det. C. A. Robertson (1 ♂/♀ INHS IC-368880)
USA: Illinois: Macoupin Co., Carlinville, 15 Jun 1904, col. C. A. Robertson, det. C. A. Robertson (1 ♂/♀ INHS IC-368881)
USA: Illinois: Macoupin Co., Carlinville; off *Thaspium trifoliatum* var. *trifoliatum* (as *T. aureum* var. *trifoliatum*), 14 Jun 1897, col. C. A. Robertson, det. as *Prosopis thaspii* Robertson 1898 (1 ♀ paratype INHS IC-179708)
USA: Illinois: Macoupin Co., Carlinville, 11 Jun 1897, col. C. A. Robertson, det. C. A. Robertson (1 ♂/♀ INHS IC-368879)
USA: Illinois: Macoupin Co., Carlinville, 9 Jun 1897, col. C. A. Robertson, det. as *Prosopis thaspii* Robertson 1898 (1 ♀ Lectotype INHS IC-179707)
USA: Missouri
USA: Missouri: Franklin Co., Engelmann Woods Natural Area; off *Sanicula odorata* (as S. gregaria), 21 May 2008, col. M. Arduser, det. M. Arduser (1 ♂ M. Arduser Private Collection)
USA: Missouri: McDonald Co., Huckleberry Ridge Conservation Area, 2.5 m E. of Pineville; off *Chaerophyllum procumbens*, 15 Apr 2006, col. R. P. Jean, det. M. Arduser (2 ♂ M. Arduser Private Collection)
USA: Missouri: Greene Co., Rocky Barrens, Conservation Area, NE Willard 1.5 mls, T30NR22WS.19(N2); off *Physaria filiformis*, 14 Apr 2006, col., M. Arduser, det. M. Arduser (2 ♂ M. Arduser Private Collection ARD8090; ARD8470) (Edens-Meier et al. 2011)
USA: Missouri: Franklin Co., Shaw Nature Reserve (Ozark Mountains); off *Zizia aptera*, 10 May 2002, col. R. Clinebell, det. M. Arduser (1 ♀ M. Arduser Private Collection)
USA: Missouri: Lewis Co., Accola Woods Preserve (Glaciated Till Plains), 5 May 2002, col. M. Arduser, det. M. Arduser (1 ♂ M. Arduser Private Collection ARD4120)
USA: Missouri: Laclede Co., Bennett Spring State Park (Ozark Mountains); off *Zizia* sp., 2 May 2001, col. M. Arduser, det. M. Arduser (7 ♀ M. Arduser Private Collection ARD5584; ARD5585; ARD5586; ARD5587; ARD5588; ARD5589; ARD5938)
USA: Missouri: Dallas Co., Bennett Spring State Park (Ozark Mountains); off *Taenidia integerrima*, 1 May 2001, col. M. Arduser, det. M. Arduser (2 ♂ 2 ♀ M. Arduser Private Collection ARD5579; ARD5580; ARD5581; ARD1538)
USA: Missouri: Franklin Co., Engelmann Woods Natural Area, 25 Apr 1987, col., M. Arduser, det. M. Arduser (1 ♂ M. Arduser Private Collection ARD5577)
USA: Texas
USA: Texas: Brazos Co., Lick Creek Park, College Station; off *Crataegus* sp., 16 Mar 2012, col. J. L. Neff, det. J. L. Neff (2 ♂ CTMI 35443; 35447)
USA: Texas: Bastrop Co., Camp Swift; off *Salix nigra*, 31 Mar 2004, col. J. L. Neff, det. J. L. Neff (1 ♂ CTMI 26657)
USA: Texas: Bastrop Co., Camp Swift; off *Salix nigra*, 10 Apr 2003, col. J. L. Neff, det. J. L. Neff (1 ♀ CTMI 24636)
USA: Texas: Limestone Co., 5 miles S of Mexia; off *Phacelia patuliflora*, 6 Apr 1988, col. J. L. Neff, det. J. L. Neff (1 ♀ CTMI K05837)
USA: State/County unknown
USA: date unknown, col. C. A. Robertson (1 ♂/♀ NCSU/ Charles Robertson Collection NCSU10323)

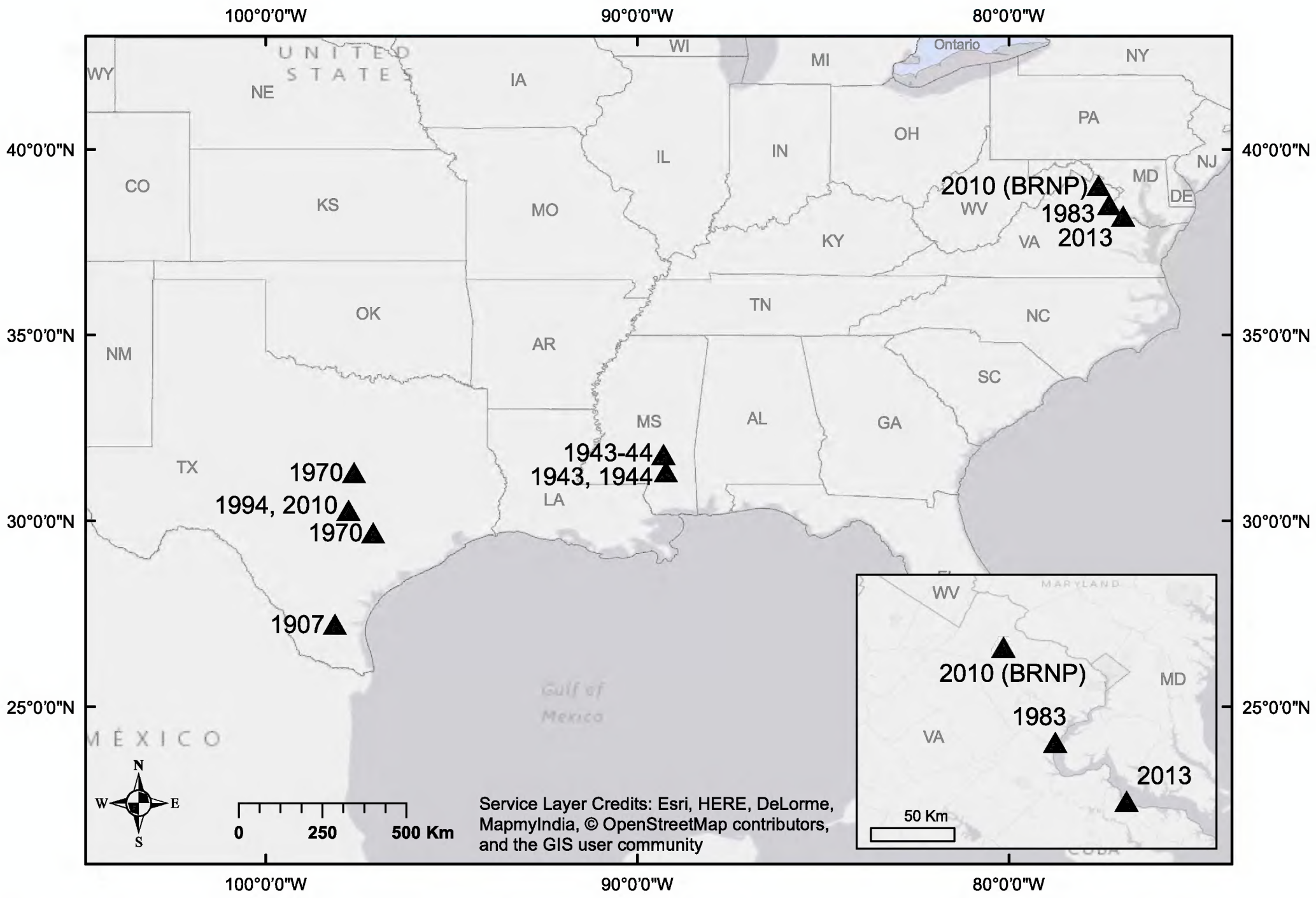

Figure 3. Map summarizing *Anthophorula* (*Anthophorisca*) *micheneri* (Timberlake, 1947) historical and modern collection events in the United States. Map Insert: Northern Virginia, showing recent and BRNP collection events.

micheneri at BRNP in September 2010, a male specimen was collected in September, 2013 by R. Morawe in Colonial Beach, Virginia (38.1979°, −76.9285°) 109 km southeast of BRNP. Two female specimens of *A. micheneri* (located in the NMNH National Collection in 2010) were collected in October 1983 by R. Duffield (Howard University, District of Columbia, USA) at Quantico Marine Base (62 km southeast of BRNP), whose boundaries intersect Prince William, Stafford, and Fauquier counties in northeastern Virginia. Duffield's *A. micheneri* specimens were identified by George Eickwort and labeled as *Exomalopsis micheneri* Timberlake, 1947 and were collected from *Agalinis setacea* (J. F. Gmel.) Raf. (as *Gerardia setacea*) (ITIS 2014). A third female specimen also identified by George Eickwort as *A. micheneri* in the National Collection at NMNH was collected in or near the town of Falfurrias, Texas by A. C. Morgan in 1907 but appears not to be the same species. All other collection records examined by the authors indicate that *A. micheneri* has not been collected in the United States (U.S.) any further north and east than Hattiesburg, Lamar and Forrest counties in southern Mississippi (1,353 km southwest of Quantico Marine Base and 1,364 km southwest of BRNP, VA respectively) (Figure 3). Thus the NMNH specimens along with recent collections from the BRNP and Virginia Beach represent an extension of the known range of *A. micheneri* of over 1,350 km (Table 1).

The scientific name of a species is often the central datum to which all other existing information about the species is linked. Therefore, an understanding of the species' taxonomy is key to the successful search and detection of historical collection records for the species. Charles D. Michener collected the female holotype of *A. micheneri* from Hattiesburg, Mississippi in October 1943, which was first described as *Exomalopsis (Anthophorula) micheneri* in Timberlake's (1947) revision of the species of *Exomalopsis* Spinola, 1853 occurring in the United States. The holotype specimen is currently stored in the collections of the American Museum of Natural History, New York (AMNH 2014). Michener also collected 2 male and 15 female paratype specimens of *A. micheneri* from the same type locality (at least 10 of which are reported to also reside in the collections at AMNH); and 2 more female paratypes from Camp Shelby, near Hattiesburg, Lamar County, Mississippi in 1943 and 1944. Timberlake (1947) states that all of these specimens were collected off *Agalinis purpurea* (L.) Pennell (as *Gerardia purpurea*)

(family Orobanchaceae) (ITIS 2014). Michener and Moure (1957) proposed a new subgenus *Anthophorisca* of *Exomalopsis*, which included *A. micheneri* as *Exomalopsis* (*Anthophorisca*) *micheneri*. Timberlake (1980) retained the *E.* (*Anthophorisca*) *micheneri* taxonomy in his review of North American *Exomalopsis*. But the subgenus and species was moved to *Anthophorula*, which was elevated to genus by Silveira (1995), with the taxonomy currently settled at *Anthophorula* (*Anthophorisca*) *micheneri*. The distribution of all species in the *Anthophorisca* subgenus has been consistently described as restricted to the southern and central United States, as far north as central California, Utah, Colorado, Nebraska, and Indiana; east to Mississippi and south to Oaxaca, Mexico (Michener and Moure 1957; Silveira 1995; Michener 2007). However, with the exception of the *A. micheneri* occurrence records described here for Virginia, historical collection records examined to date indicate restriction of this particular species' distribution only to the south-central U.S. (Texas and Mississippi) with a notable absence in the southeastern U.S.

Timberlake referenced a series of 118 specimens of *A. micheneri* collected off the same plant species (*Agalinis purpurea*) at two sites in Flatonia, Fayette County, Texas by Baker, Kamm, and Michener on 12 September 1970 (Timberlake 1980). Although this plant species has been recorded in neighboring Washington County and other counties east of Fayette County, Texas, J. L. Neff (pers. comm. 2012) suggests that Baker, Kamm, and Michener's *A. purpurea* identification was likely a misidentification of the plant as that species is not known to occur in Fayette County, while other species of *Agalinis* it is easily confused with, such as *A. strictifolia* (Benth.) Pennell and *A. heterophylla* (Nutt.) Small, do occur in that location (USDA PLANTS 2014a, 2014b). Neff also reported collecting *A. micheneri* from *Agalinis strictifolia* in Texas in September and October 1994, and in September 2010. *Agalinis purpurea*, along with *Agalinis tenuifolia* (Vahl) Raf. var. *tenuifolia*, is native to and has been recorded historically and more recently in Loudoun County, VA, while *A. setacea* occurs in Virginia but has not yet been recorded specifically in Loudoun County (Virginia Botanical Associates 2014). *Agalinis strictifolia* occurs only in Texas (National Museum of Natural History 2014b; USDA PLANTS 2014a, 2014b). No species in the genus *Agalinis* were recorded in flower at site 5 at BRNP during the 2010–2011 study. However a 2004 floristic survey of the broader Eastern Goose Creek Watershed that encompasses the BRNP did detect *Agalinis* species (Williams pers. comm. 2012). Accurate plant identification is important especially when potential species associations are being reported. Thus in addition to reporting the name(s) of the taxonomist(s) who confirmed the insect specimen identification and the disposition of the insect specimens, researchers and authors should also report the same information for the plants, and where appropriate, associated plant specimens from which the insects were collected (Vink et al. 2012).

Hylaeus sparsus (Cresson) (Colletidae: Hylaeinae)

While *Hylaeus sparsus* is known to have a relatively broad geographic distribution ranging from southeastern Canada south to Georgia, USA, west to central Texas, and northwest to Indiana (Mitchell 1960; Snelling 1968; Michener 2007), its collection in 1997 and 2011 are the only occurrences of the species in Virginia known to date (Figure 4). And the more recent collection of two female specimens from southern Saskatchewan, Canada in 2013 is a further western extension of the species' known range in Canada and North America.

Specimen records gathered to date indicate that at least 115 specimens of *H. sparsus* have been collected and documented in the U.S. and Canada, usually singly during individual collection events, between 1867 and 2013 (Table 2). *Hylaeus sparsus* (Cresson, 1869) was originally described by Ezra T. Cresson as *Prosopis sparsa* Cresson, 1869 from a female specimen collected in Pennsylvania in 1867 (Cresson 1869; AMNH 2014a). Robertson (1898) described *Prosopis thaspii* Robertson, 1898 from two female specimens he collected in 1897. Metz (1911) in a revision of the genus *Prosopis*, synonymized *P. sparsa* under *P. modestus* Say, 1837, and described a new species *P. potens*. Michener (1942), while treating *Hylaeus* as the valid genus for species formerly included as *Prosopis*, described a monotypic subgenus *Hylaeus* (*Metziella*) to include *H. potens*. Krombein (1958) listed *H. sparsus* as a valid species, along with *Hylaeus thaspii* (Robertson) as a new synonym based on T. B. Mitchell's examination of the type specimens of both names. Two years later, Mitchell (1960) recognized both *H. potens* and *H. sparsus* as members of the subgenus *H.* (*Metziella*). Snelling (1968) subsequently synonymized *H. potens* under *H.* (*Metziella*) *sparsus* (Hurd 1979; Michener 2007).

Hylaeus sparsus has been collected off or observed visiting (the latter in the case of Robertson (1929)) plant species in the U.S. and Canada from the following families – APIACEAE: *Thaspium trifoliatum* var. *trifoliatum* (L.) A. Gray (as *T. aureum var. trifoliatum*) (1 ♀ in 1897), *Perideridia americana* (Nutt. Ex DC.) Rchb.) (as *Eulophus americanus*) and *Osmorhiza longistylis* (Torr.) DC (Robertson 1929) (1 ♂/♀ in 2006), *Taenidia integerrima* (L.) Drude (2 ♀, 2 ♂ in 2001), *Zizia* sp. (7 ♀ in 2001), *Z. aptera* (A. Gray) Fernald (1 ♀ in 2002), *Z. aurea* (1 ♀ in 1914, 1 ♂ in 2002, 2 ♀ in 2003, 2 ♀, 2 ♂ in 2007), *Chaerophyllum procumbens* (L.) Crantz (2 ♂ in 2006), and *Sanicula odorata* (L.) W.D.J. Koch (as *S. gregaria* E.P. Bicknell) (1 ♂ in 2008); – BORAGINACEAE: *Phacelia patuliflora* (Engelm. & A. Gray) A. Gray (1 ♀ in 1988), *P. purshii* Buckley (5 ♂ in 2002), and *Physaria filiformis* (Rollins) O'Kane &

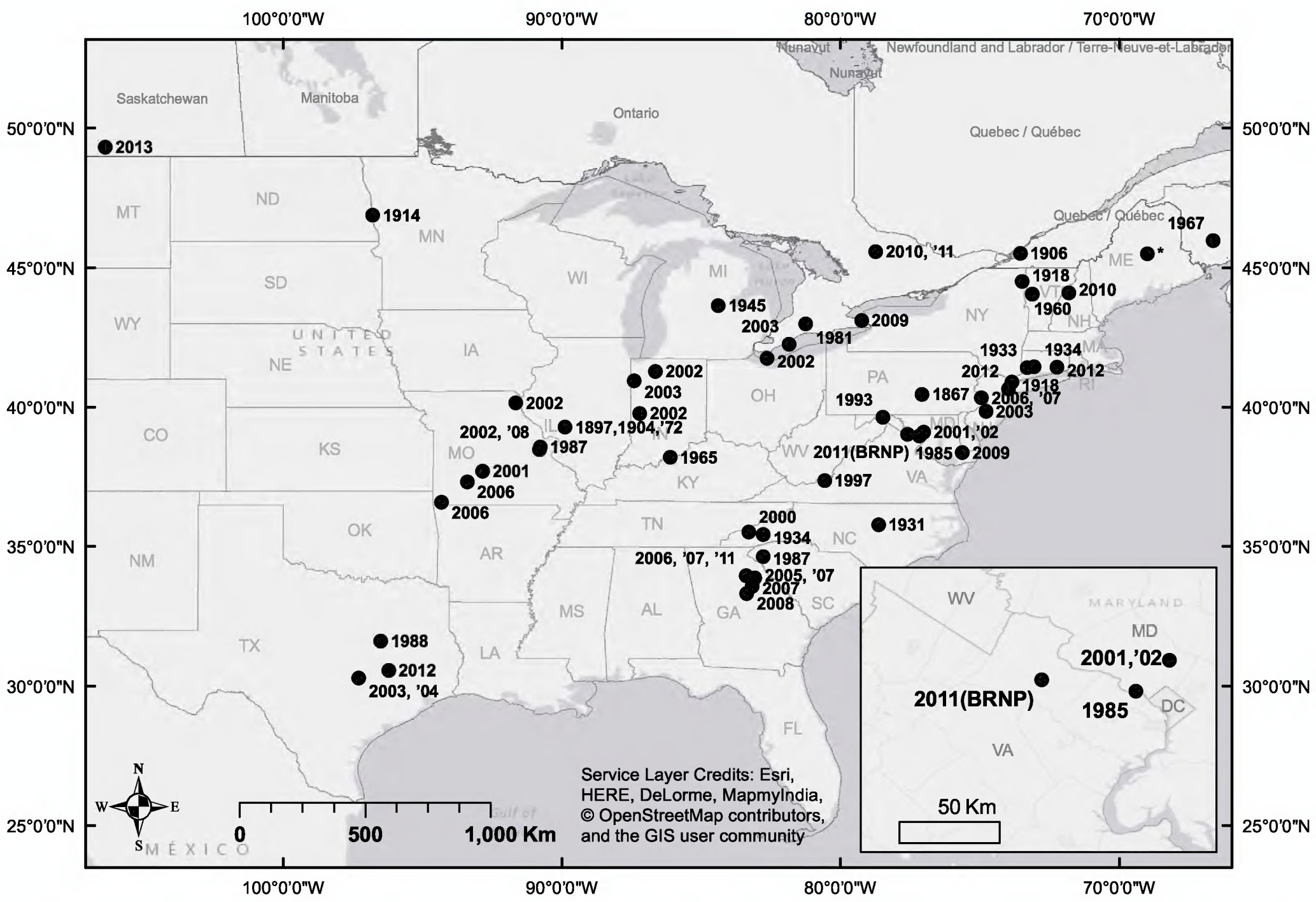

Figure 4. Map summarizing *Hylaeus* (*Metziella*) *sparsus* (Cresson, 1869) historical and modern collection events in the United States and Canada. Map Insert: Northern Virginia, showing BRNP collection event. *AMNH_BEES1582 (Maine) – unconfirmed.

Al-Shehbaz (2 ♂ in 2006); – ROSACEAE: *Rubus alleghenicensis* Porter (with specimens from *P. patuliflora* above) and *Crataegus* sp. (2 ♂ in 2012); – SALICACEAE: *Salix nigra* Marshall (1 ♀, 1 ♂ in 2003 and 2004 respectively); – FABACEAE: *Lupinus* sp. (1 ♂ in 2010); – CORNACEAE: *Cornus canadensis* L. (1 ♀ in 2011); – ASTERACEAE: *Erigeron philadelphicus* L. (1 ♀ in 2007); and – CELASTRACEAE: *Euonymus alatus* (Thunb.) Siebold (1 ♂ in 2003) (Table 2).

Females of several species in the Colletidae family are either oligolectic or "exhibit narrow polylectic tendencies" (Hurd 1979: 1748). Although records show collection of females of *H. sparsus* off *Salix nigra* in Texas, *Erigeron philadelphicus* in Pennsylvania, and *Cornus canadensis* in Ontario, Arduser notes that to his knowledge females of the species have never been collected from any family of plants other than the Apiaceae in the Midwestern U.S., while males have been found on flowers of plant species in other families as evidenced by the historical collection records examined here (Arduser, pers. comm. 2012). If this affiliation with plants in the Apiaceae also holds true for females in the Eastern U.S. then future detection efforts could focus on the plant species in the Apiaceae family mentioned by other collectors.

Apiaceae species currently known to occur within the Eastern Goose Creek Watershed include *Thaspium barbinode*, *Osmorhiza longistylis*, *Daucus carota* L., and the early flowering spring ephemeral *Erigenia bulbosa* (Michx.) Nutt. within the Preserve itself (Williams 2004; Cour 2008). *Thaspium trifoliatum*, *Chaerophyllum procumbens*, *Sanicula odorata*, *Taenidia integerrima*, *Zizia aurea*, and *Z. aptera* are (or were historically) present in both Giles and Loudoun County (USDA PLANTS 2014a, 2014b; Virginia Botanical Associates 2014). Historical collection locations for these plants in northern Virginia may no longer exist due to rapid development. And neither Williams (2004) nor Cour (2008) list any of these species for the Eastern Goose Creek Watershed and the BRNP respectively. No information has been found to indicate detection or collection of *Perideridia americana* in Canada or any U.S. State bordering the east coast to date (Botanic Garden and Botanical Museum Berlin-Dahlem 2014; Field Museum 2014; Harvard University 2014; iNaturalist.org 2014; Missouri Botanical Garden 2014; NatureServe 2014; Royal Botanic Gardens, Kew 2014; New York Botanical Garden 2014; Plants of Canada Database 2014; University of California, Davis 2014;

University of Connecticut 2014; University of Kansas Biodiversity Institute 2014; University of Tennessee, Knoxville 2014; USDA PLANTS 2014a, 2014b). However, this plant species' distribution in the U.S. is similar to that of *H. sparsus* in states in the western portion of the Mississippi River watershed (USDA PLANTS 2014a, 2014b). *Phacelia patuliflora* is found only in Texas, and while *P. purshii* is present in some counties in Virginia, these do not include Giles or Loudoun (USDA PLANTS 2014a, 2014b). Field-based behavioral observations or an analysis of pollen extracted from the specimen (pollen is carried internally by this species (Mitchell 1960)), at the time of collection may determine whether or not this species was actively foraging on the flowers of *Asimina triloba* at the time of capture.

Arduser describes *H. sparsus* (in the Midwestern U.S.) as a vernal univoltine natural community-dependent species and primary oligolege of Apiaceae, restricted to woodlands and forests. That is to say, *H. sparsus* is a species that occurs in relatively intact, high quality diverse natural habitats rather than back yards, old fields, roadsides, etc., (Arduser pers. comm. 2014). He considers its conservation status in the Ozark Mountains of Missouri to be secure, but this may not be the case throughout its entire range. Michener (1979: 287) listed the Hylaeinae as being "most abundant and diversified in mesic or humid areas". Collection records and published references to this species being collected in or near riparian or seasonally flooded forests, piedmont watersheds and bottomland habitats such as those associated with the Oconee River in Georgia (Ulyshen et al. 2010; Hanula and Horn 2011; Hudson 2013; Hanula, pers. comm. 2014); Tanglewood Spring in South Carolina; Cascade Falls and Goose Creek in Virginia; and in and around the shores of Lake Erie, Ontario (Marshall 2009; University of Guelph 2014) may be purely coincidental, a reflection of collectors' habits, or may suggest a possible habitat affinity worth further exploration. Mitchell (1960) describes the nesting habit of *Hylaeus* species as including the pithy stems of plants such as sumac (*Rhus* L.), at least two species of which *Rhus copallinum* L. and *Rhus glabra* L. occur at BRNP among numerous other pithy stemmed plant species such as those in the genus *Rubus* L. (Williams 2004; Cour 2008). *Hylaeus* species are also known to nest in pre-existing tunnels and burrows in rocks or soil (Mitchell 1960; Barrows 1975; Michener 1979). The BRNP sites were not inspected for these signs as part of this study.

These new data for *Anthophorula micheneri* in Virginia, USA extend the known geographic distribution for this species and indicate that although rarely detected this species may exhibit a broader distribution across the United States than initially suspected. This new detection and historical records indicate that collecting later in the year (September – October) and especially from flowers of plants in the genus *Agalinis* may reveal more information about *A. micheneri*'s distribution and foraging habits in the U.S. The Virginia records for *Hylaeus sparsus* in combination with the historical collection records and plant associations published here, advance our knowledge of this rare species and indicate possibilities for further study of its habitat preferences and foraging habits, especially on plant species in the family Apiaceae.

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